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Hudson river tunnels; an
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THE HUDSON RIVER TUNNELS

SPECIFICATIONS

FOR THE



UNDER THE

HUDSON RIVER,

AT

ALBANY, N. Y.

BY R. HIGHAM, CIVIL ENGINEER.

ALBANY :
WEED, PARSONS AND COMPANY.
1853.

THE HUDSON RIVER TUNNELS
AN ANNOTATED BIBLIOGRAPHY

Compiled by Joseph B. Rivlin

New York
1935

S.L.S.

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VS Nov. 5, 1936 / HEC

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INTRODUCTION

This list contains selected references to the technical literature, in English, relating to the tunnels constructed, or in progress under the Hudson river between New York and New Jersey. I have excluded articles appearing in general "popular" periodicals, and debative ^{able} material on bridge versus tunnel.¹ Further limitations exclude extensions of the tunnels into the mainland, cross-town, and under the East river, New York city, and all references to tunnels planned, but on which construction has not yet begun.²

In general, two policies have been followed for selection:-

- (1)- An historical record of the progress of construction.
- (2)- The inclusion of some material duplicated in several periodicals, offering a selection for general libraries which may not subscribe to all the serials referred to in the list.

The history of tunneling under the Hudson really begins with the experimental undertaking of Haskin in 1869--the first major application of compressed air in under-water tunneling-- and continues with the Midtown-Weehawken tunnel, now in progress. We can only refer to the exhaustive researches carried out in the Pennsylvania railroad tunnel projects; and further remark that the Holland tubes were almost pioneer experiments in the ventilation of tunnels of their type. Although this bibliography has a strictly local limitation, it soon became evident, in the process of compilation, that a review of construction under the Hudson river includes a record of contemporary methods of subaqueous tunneling in general.

I believe the arrangement by topic should be useful, as Hudson tunnel practice can be applied to the construction of any under-water tunnels. The brief Chronology is offered as an approximate guide in the selection of material relating to a particular tunnel.

Mention of the "North river" refers to the southern part of the Hudson river, forming part of the harbor of New York.

¹The bibliography of the Municipal reference library includes material on the bridge-tunnel question. See Items 131-132.

²For the purpose of record, I am including the facsimile title-page of the earliest pamphlet which I have found relating to a Hudson tunnel planned but not yet constructed. See Plate I (frontispiece).

CHRONOLOGY

HUDSON-MANHATTAN R.R.

1874.	November.	Construction started.
	Dec. 15.	Work stopped by injunction.
1879.	September.	Work resumed after litigation.
1880.	July 21.	First major accident causes drowning of 20 men.
	October.	Recover bodies of drowned men; regular construction resumed.
1882-		
1887.		Various periods of suspension and resumption of work; due to lack of funds.
1888.	March.	Construction resumed under contract with Pearson and Sons, Ltd.
1891.	August.	Work suspended owing to lack of funds.
1902.		Construction resumed under direction of C.M.Jacobs for N.Y. & Jersey R.R.
1905.	May.	Begin construction of South tubes.
1908.	Feb. 25.	Official opening- North tubes.
1909.	July.	Official opening-South tubes.

PENNSYLVANIA R.R.

1904.	April 1.	Construction started.
1910.	Nov. 27.	Official opening.

HOLLAND VEHICULAR.

1920.	Oct. 12.	Construction started.
1927.	Nov. 13.	Official opening.

MID-TOWN VEHICULAR.

1934.	May 17.	Construction started.
1938.		Estimated date of completion.

BOOKS AND PAMPHLETS

- 1880.
1. DOWD, Olney S. Safe and rapid mode of tunneling the Hudson and similar rivers. N.Y., Dickson, 1880. 20p. illus.
Description of his Dowd system. Extracts in: Engineering News, v.7, p.362-63, 1880.
- 1882.
2. DRINKER, Henry S. Tunneling, explosive compounds, and rock drills. Giving the details of practical tunnel work... comprising a review of tunneling from the reign of Rameses II. to the present time. 2d ed. N.Y., Wiley, 1882. 1143p. illus.
First ed., 1878. Includes chapters on subaqueous tunneling, surveying, ventilation and costs. The second ed., only, includes an article by Charles Kirchhoff on the Hudson river tunnel, (p. 961-76).
- 1885.
3. BURR, S. Devere. Tunneling under the Hudson river; being a description of the obstacles encountered, the experience gained, the success achieved, and the plans finally adopted for rapid and economical prosecution of the work. N.Y., Wiley, 1885. 70p. 10 plates.
- 1906.
4. COPPERTHWAIT, William Charles. Tunnel shields and the use of compressed air in subaqueous works. London, Constable, 1906. 389p. illus.
Pages 159-72 describe the construction of the Hudson-Manhattan tunnels.
 5. STAUFFER, David McNeely. Modern tunnel practice, illustrated by examples taken from actual recent work in the U.S. and in foreign countries. N.Y., Eng. news pub. co., 1906. 314p. illus.
- 1909.
6. JERSEY city (N.J.). Free public library. From canoe to tunnel; a sketch of the history of transportation between Jersey city and New York, 1661-1909. Jersey city, 1909. 16p. illus.

BOOKS AND PAMPHLETS

1910.

7. NEW York tunnel extension; the Pennsylvania railroad.
Description of the work and facilities. N.Y., 1910.
2v. illus.

Contains sixteen papers reprinted from the American society of civil engineers. Transactions, v.68-9, 1910. An exhaustive analysis of all stages in the construction of the tunnels from New Jersey into New York, and also the extensions into Brooklyn and Queens, L.I., under the East river. The following Contents are of papers on the Hudson river tunnels:--v.1. The N.Y. tunnel extension of the Pennsylvania railroad, by C.W. Raymons.--the North river division, by C.M. Jacobs.--The North river tunnels, by S.H.M. Hewett and W.L. Brown.--v.2. Discussion on papers.--Subject index.--Author index.

The papers by Raymond, Jacobs, and Hewett have also been printed in Amer. soc. civil eng. proc., v.35, p.857-87, 1909; v.36, p. 134-63, p.690-840, 1910, respectively.

1912.

8. GILBERT, Gilbert H., and others. The subways and tunnels of New York; methods and costs. With an appendix on tunneling machinery and methods, and tables of engineering data. N.Y., Wiley, 1912. 372p. illus.

With Lucius I. Wightman and William Lawrence Saunders. Technical treatise on all phases of construction of the Hudson-Manhattan and Pennsylvania tubes, as well as of the East river and other tunnels of the city. Includes brief histories of the projects.

9. PRELINI, Charles. Tunneling: a practical treatise... 6th ed. N.Y., Van Nostrand, 1912. 349p. illus.
First ed., 1901.

1917.

10. PUBLIC service corporation of New Jersey. Report to the executive committee... on the proposed vehicular tunnel between the cities of Jersey city and New York, by the special committee appointed to investigate the subject. Newark, N.J., 1917. 137p. illus.
Discusses the traffic need, feasibility and cost, including Results of air analysis in experimental tunnel.

1922.

11. BRUNTON, David William, and John A. Davis. Modern tunneling ... with new chapters on railroad tunneling by J. Vipond Davies. 2d ed. N.Y., Wiley, 1922. 612p. illus.
First ed., 1914, lacks the Davies chapters. Bibliography, p. 360-419, 568-76.

BOOKS AND PAMPHLETS

1922.

12. HEWETT, Bertram Majendie, and S. Johannessen. Shield and compressed air tunneling. N.Y., McGraw, 1922. 465p. illus.

Comprehensive text-book on shield tunnels, emphasizing the basic principles and practice. Facts obtained chiefly from the authors' "unbroken series of observations commenced during the construction of the tunnels" of the Pennsylvania railroad under the Hudson river. Includes chapters on history, plant and equipment, progress and cost, survey, and compressed air sickness. Bibliographies, p. 37-52, 437-45.

1927.

13. JERSEY Observer. Holland tunnel, historical number, commemorating the opening of America's only vehicular tunnel linking N.Y. and New Jersey, Nov. 12, 1927. Hoboken, N.Y., 1927. 4 parts in 1. illus.

Fully illustrated, feature supplement of the newspaper.

1928.

14. NEW Jersey. Interstate bridge and tunnel commission. Report. 1909-27. Trenton, N.J., 1913-28.

None issued in 1915 or 1918. Superseded by Part of New York authority. Annual report.

1930.

15. NEW York (state). Bridge and tunnel commission. Report. 1906-29. Albany, 1907-30.

Superseded by Part of New York authority. Annual report.

16. STURTEVANT, B.F., Co. The eighth wonder. Boston, Sturtevant co., 1930. 68p. illus.

Written by Carl C. Gray and H.F. Hagen. Popularly written history and description of the work, with special emphasis on the ventilation equipment manufactured by the company. Also reprinted; see item 41.

1931.

17. PORT of New York authority. Report on preliminary investigation for midtown Hudson tunnel between Manhattan, N.Y. city and Weehawken, N.J. Jan. 9, 1931. Albany, 1931. 23p. illus.

includes report of the chief engineer, O.H. Ammann, on traffic studies, surveys, designs and financial studies.

1933.

18. PORT of New York authority. Midtown Hudson tunnel. Contract MHT 1A-3. N.Y., 1933.

Contents.--1A. River berings.--2. Cast iron and steel tunnel lining.--3. Belts, nuts and washers for tunnel lining.

BOOKS AND PAMPHLETS

1934.

19. PORT of New York authority. Annual report. 1-14, 1921-1934. Albany, 1922-35.

HUDSON-MANHATTAN R.R. TUNNEL

1879.

20. THE HUDSON river tunnel. (Eng. N. 6:391. Nov.29,1879).
Summary of work done to-date.

1880.

21. THE HUDSON river tunnel. (Eng. N. 7:248-50. July 24,1880). illus.
A reporter summarizes the progress on the tunnel, and narrates his own experiences during a trip through the tunnel. Brief comment by engineers on the accident.

22. THE HUDSON river tunnel. (Eng. N. 7:272-73,279. Aug.,1880).
Editorial comment on efforts being made to recover the bodies of the drowned workmen.

1886.

23. THE HUDSON tunnel experiment. (Eng. N. 15:297. May 8,1886).
Editorial comment questioning Haskin's claims in his suit against Andersen for infringing his "pilot tunnel" patent.

1889.

24. THE HUDSON river tunnel. (Eng. N. 22:318. Oct. 5,1889).
Announces work to be resumed under Fowler and Baker. Figures of progress to-date.

1890.

25. PROGRESS of the great railway tunnels under the Hudson river between N.Y. and Jersey city. (Sci. Amer. 63:279-80. Nov. 1, 1890). illus., plan.
Brief resume of the history to-date, description of the shield, and method of carrying on the work.

1903.

26. THE HUDSON river tunnel. (Sci. Amer. 89:132-33. 1903). illus., plan.
Summary of progress to-date.

1904.

27. BURR, S.D.V. Notes on the early history of the Hudson river tunnel. (Railr. gaz. 46:421-22. 1904).
Narrates a few incidents during the early construction.

HUDSON-MANHATTAN

1904.

28. THE HUDSON river tunnel. (Sci. Amer. 90:253-54. 1904).
illus.,map.
feature article, a brief summary of the completed project.
29. THE ORIGINATOR of the Hudson river tunnel. (Eng. N. 51:343. 1904).
Review of D.C.Haskin's relations with the Hudson tunnel.

1905.

30. PROGRESS of the N.Y. tunnels and subways. (Sci. Amer. 93:459-61.
Dec. 9, 1905); illus.
Summary of progress to date; brief explanation of surveying
method in building the tunnel around a curve.

1908.

31. BURR, S.D.V. The tunnels of the Hudson companies. (Amer.
inst. mining eng. Bimonthly bull. no.20,p.253-74. March 1908).
illus.,diags.,map.
Non-technical,historical narrative of the completed tunnels.
32. THE CROOKEDNESS of the Hudson tunnel. (Sci. Amer. 98:178. 1908).
Editorial explaining the distortions as due to the crushing
of the shell of the old Haskin tunnel.
33. JACOBS, Charles M. The engineering difficulties of the Hudson
and manhattan tunnel. (Railr. gaz. 44:399. 1908).
Mentions the more striking problems which had been solved.
34. THE OPENING of the first Hudson tunnel. (Eng. N. 59:230-34.
1908). illus.,map.
An historical chronology, followed by a condensed review of
the completed work. Letter from Walton I. Ains offers some
corrected figures for the shield (p.259).

PENNSYLVANIA R.R. TUNNEL

1904.

35. THE PENNSYLVANIA tunnel at N.Y. city. (Sci. Amer. 90:42.
1904). plan.
Outline of the location and progress of the tunnel.

1905.

36. THE NEW Jersey tunnels and subways. (Sci. Amer. 93:122-23.
1905). map.
Describes the relations of the tunnels and railways to
the N.Y. subways.

1907.

37. THE ENGINEERING staff of the Pennsylvania R.R. Hudson river
tunnels. (Eng. N. 57:249. 1907).
Group photograph.

PENNSYLVANIA R.R.

1910.

38. INAUGURAL of the N.Y. extension of the Pennsylvania railroad: opening of the passenger station. (Eng. N. 64:267-75. 1910). diags., illus., map.
Brief history and description of the completed structures; dimensions of the tunnels. Editorial: p. 284.

HOLLAND VEHICULAR TUNNEL

1920.

39. OPPOSE two-line Hudson vehicle tunnel. (Eng. N. 84: 593-94. March 18, 1920).

Developments at a public meeting held by the National highway traffic association, and the resolution that investigations should be made of a larger tunnel than the one being then contemplated.

1922.

40. SPECIFICATION details of Hudson river vehicle tunnel. (Eng. N. 88:574-75. 1922). diags.

Brief summary of the contracts for construction of the twin tubes.

1930.

41. GRAY, Carl C., and H.F.Hagen. The eighth wonder: the Holland vehicular tunnel. (Smithsonian inst. Ann.report. 1929/30. p.577-607). diags., illus., maps, plans.

Reprinted, with some omissions, from the pamphlet of the Sturtevant co. See item 16.

MIDTOWN VEHICULAR TUNNEL

1930.

42. PLAN second highway tunnel under Hudson river. (Eng. N. 104: 454-56, 1930). diagr., maps.

The plans of the Interstate joint tunnel commission compared with those of the Port authority as to location and costs; additional data: p.531.

1934.

43. SECOND vehicle tunnel to be built at N.Y. (Eng. N. 112:313-15. 1934). diagr., map.

Outlines major features planned in the contracts.

1935.

44. MEN against the river. (Pop.mech. 63:402-05. March, 1935). illus.
Experiences during a visit "below", with a brief outline of the project.

GENERAL

1880.

44. SPIELMANN, Arthur, and C.B.Brush. The Hudson river tunnel. (Amer. soc. civil eng. Trans. 9:259-77, 1880) diagrs., illus., tables.
Progress of construction up to May 1880. Discusses the shaft, air lock, lining, heading and atmosphere. Also in Eng. N., v.7, p.265-67, 1880, (complete text, omitting some illustrations).

1882.

45. THE HUDSON river tunnel--the N.Y. works. (Eng. N. 9:306-08, 1882). diagrs., and inset.
Description of the caisson, bulkhead, and C.W.Clift sand pump.
46. SMITH, William Seay. The Hudson river tunnel. (Amer. soc. civil eng. Trans. 11:314-24, 1882). diagrs.
General description of the project and work done to date.
Emphasis on application of compressed air in the construction.

1903.

47. THE HUDSON river tunnel (Eng. rec. 48:95-98, 1903). diagrs., illus.
History of the construction, and outline of the equipment; detail of the Roebling cable-hauling system of the north tunnel. Also, abstract, in Eng.mag., v.25, p.909-12, 1903.

1906.

48. FORGIE, James. The construction of the Pennsylvania R.R. tunnels under the Hudson river at N.Y. city. (In two parts). (Eng.N. 56: 603-14, 1906; 57:223-34, 1907). diagrs., illus., tables.
Part 1: Tunnel design, lining and plant. Part 2: Driving the tunnel.
Fully illustrated description of the methods and working conditions. Includes chapters on survey work, the shield, and surface plant. Tables of the staff organization, and rates of progress.
Editorial comment: v.56, p.19; v.57, p.243.

1910.

49. JACOBS, Charles Mattathias. The Hudson river tunnels of the Hudson and Manhattan company. (Inst. civil eng. Minutes of proc. 161:169-257, 1910). diagrs., tables.
Exhaustive paper on the tunnel by the chief engineer who saw the work to completion. Technical sections include discussion of the caisson, stability of the tunnels in silt, stations and cost.

1915.

50. SNYDER, G.D. Subaqueous highway tunnels. (Amer. soc. civil eng. Trans. 78:252-311, 1915). diagrs., maps, plans.
Largely a compilation of "published facts relative to all the subaqueous highway tunnels in the world". Pages 276-77 refer to the N.Y. project.

GENERAL

1917.

51. TUNNEL under the Hudson designed for vehicular traffic. (Eng. N. 78:132-35, 1917)✓ diags.,map.
Summary of recommendations of the Board of engineers in its report to the Public service corporation of N.J.

1919.

52. THE PROPOSED N.Y. and N.J. vehicular tunnel. (Amer. soc. civil eng. Proc. 45:249-300, 1919). diags.,illus.
Informal discussion of the merits of various types of tunnel construction. Short history of the proposed Hudson tunnel by E.A.Byrne. J.F. O'Rourke explains his proposed plans. Summary by Charles E. Fowler in Sci.Amer.,v.120, p.337,358, April 5,1919.
53. SCHREIBER, Martin. Vehicular tunnels under the Hudson river. (Franklin inst. Jour. 187:273-88, March,1919). diags.,map.
Good historical summary of the Holland tunnel to date, discussing the several plans proposed, including the different ventilation schemes and tests.

1920.

54. LARGEST American shield tunnel designed to carry vehicular traffic under Hudson river. (Eng.N. 84:357-364, 1920)✓ diags.
Summary of C.M.Holland's report to the N.Y. and N.J. tunnel commissions. Estimates of traffic, economical size, types of tunnels considered and costs.

1924.

55. BUILDING the Hudson river vehicle tunnel. (Eng. N. 92:798-803, 1924)✓ diags.,illus.,map.
Summary of the methods in "driving" the tunnel. Includes figures of costs as affected by changes in structural design.

1927.

56. SKINNER, Frank W. The Holland vehicular tunnel under the Hudson river. (Engineering.124:601-6,667-71,735-38, 1927). diags.,illus.,maps.
Technical features of design, shields, shafts, safety precautions, and ventilation. Abstract in Can. eng. v.53, p.579-82, 1927.

1928.

57. SKINNER, Frank W. Design, equipment and construction of Holland vehicular tunnel. (Conn. soc. civil eng. Papers and trans. 1928, p. 91-114). illus.,map.
Summary of difficulties encountered in the planning and building of the tunnel.

DESIGN.

- 1881
58. THE HUDSON river tunnel. (Eng. N. 8:518-20, 1881),/ diags.
Describes the adapted plan of the asst. engineer, S.H.Finch.
- 1901.
59. A NEW subaqueous viaduct. (Eng. N. 45:235-37, 1901),/ diags.
Description, by F.W.Lepper, of features and practical details of F.W.Fitzpatrick's system for a double track railway line across the North river at N.Y.city.
- 1903.
60. THE PENNSYLVANIA railroad tunnel under the North river, at N.Y.city. (Eng. N. 50:331-39, 1903), diags.
Detailed plans for the Manhattan and N.J. section, and the North river tunnel section. Specifications for materials used in construction.
61. TUNNELS for the N.Y. city terminus of the Pennsylvania and Long Island railroads. (Eng. rec. 48:430-33, 1903),/ diags.
Outlines the technical features of the North river divisions. Pages 458-60 continue the description of the East river sections.

CAISSON

- 1880.
62. THE CAISSON of the Hudson river tunnel. (Eng. N. 7:319-20, 1880),/ diagr.
Perspective drawing with brief description.
- 1908.
63. TORRANCE, W.M. Special concrete structures in the Hudson river tunnels. (Western sec. eng. Jour., 13:632-61, 1908). diags.,illus.,map.
Design and construction, with reinforced concrete, of the caissons on the N.J. side of the Hudson-Manhattan railroad.
- 1921.
64. SKERRETT, Robert G. The Hudson river caissons. (Sci. Amer. 125:252, 1921),/ illus.
Non-technical description, including dimensions.
- 1922.
65. LAUNCH caisson for N.Y. vehicle tunnel shaft. (Eng. N. 89:1042, 1922),/ illus.
Explains temporary suspension of driving due to a "blow", and reviews status of the project up to launching of the caisson.

FOUNDATION

- 1887.
61. THE CENTERING in the Hudson river tunnel. (Eng. N. 18:57, 1887).
diags.
Briefly illustrates the method for adjusting or keying
the arch.
- 1902.
62. RENO, Jesse W. A method for strengthening the Hudson river
tunnels. (Eng. N. 48:543, 1902).
Letter, describing his plan for a supporting continuous
girder under the tunnel.
- 1903.
63. MANHATTAN and Weehawken shafts of the Pennsylvania railroad
tunnels under the North river. (Eng. rec. 48:601, 1903),
illus.
Summarizes the contracts, and mentions the problems faced
in construction.
64. RENO, Jesse W. An alternative plan of pile supports for the
Pennsylvania P.R. North river tunnel. (Eng. N. 50:392-93,
1903), diags.
His proposed system for driving wooden piles by hydraulic
pressure.
- 1904.
65. DRIVING a test pile for the Hudson river tunnel. (Sci. Amer.
90:324, 1904), diagr., illus.
Studies made previous to the use of piles as support for
the Pennsylvania tunnels in silt.
- 1923.
66. DRIVING 250-ft. piles for Hudson river tunnel. (Eng. N. 90:
242-48, 1923), diags., illus.
Special problems of foundation, design and construction of
the N.J. ventilation shaft.
67. RECORD job of pile driving. (Sci. Amer. 128:396-97, 1923),
illus.
Non-technical description of methods; includes dimensions
and sectional views.
68. SKINNER, Frank W. Vehicular tunnel shaft's deep foundation.
(Eng. & contr. 59:135-40, 1923), diags., illus.
Discusses the problem of design, installation and methods
finally adopted for the special pile type of foundation.

FOUNDATION

1924.

69. DRIVING piles for Hudson river tunnel. (Can. eng. 46:495-98, 1924), diags., illus.
Describes method of sinking piles for the New Jersey ventilation shaft.

LINING

1890.

70. THE SEGMENT erector of the Hudson river tunnel. (Eng. N. 24:439, 1890), diags.
Explains operation of the Meir device for putting into place the iron segments for the tunnel lining.

1892.

71. THE CAST iron lining of the Hudson river tunnel. (Eng. N. 27:609-10, 1892),
Discusses problems of cracking of the tunnel lining.
Remarks (letter) by William R. Hutten: p. 660.

1905.

72. WATERPROOFING the Pennsylvania E.R. tunnels at N.Y. (Eng. N. 53:691, 1905).
Revisions (sect. 297-98) of specifications for the tunnel work.

1920.

73. CONCRETE block vehicular tunnel investigation. (Public works. 48:549-51, 1920).
Summarizes Gen. Goethals' arguments for concrete blocks construction as offering the same structural strength at one-third to one-half the cost of cast iron linings.
74. CONTROVERSY over concrete-block construction.
(Eng. N. 84:624-26, March 25, 1920).
Divergent estimates and views expressed in the course of public hearings. Statements of C.M. Holland rejecting the concrete-block plan, and J.F. O'Rourke's estimates of comparative costs of concrete-block and cast-iron linings. Editorial comment during an early stage of the controversy: March 18, p. 552-53.
75. FORGIE, James. Hudson vehicle tunnel designs. (Eng. N. 84: 977-78, May 13, 1920).
Relevant to the Goethals-Holland controversy, a letter describing the character of the tunnel lining of the Pennsylvania railroad tubes.

LINING

1920.

76. GOETHALS, George W. Hudson vehicle tunnel discussed by Gen. Goethals. (Eng. N. 84:729-32, April 8, 1920).
Condensed from his Memorandum addressed to the joint tunnel commissions. "A clear statement of his attitude toward trench-method tunnel construction for the present enterprise, and of the ...concrete-block 'Goethals' plan' tunnel".
77. JOHANNESSON, S. and B.H.M. Hewett. Notes on tunnel lining for soft ground. (Amer. soc. civil eng. Trans. 83:1822-1918, 1920). diags., plates.
"The conclusions here arrived correspond closely to the actual behavior of tunnels driven through North river silt". With discussion.

1922.

78. TUNNEL segment casting methods. (Foundry. 50:137-41, 1922). diags., illus.
Manufacture of the castings for the iron segments of the tunnel lining.

1925.

79. LINING procedure in Holand vehicular tunnel. (Eng. N. 95: 902-07, 1925). diags., illus., map.
Full descriptions of the finishing operations incident to lining first with concrete and then with glazed tile.

ROADS

1925.

80. Vehicle tunnel under Hudson river paved with granite. (Eng. N. 95:726-27, 1925). diagr., illus., map.
Prices, dimensions and construction of the granite blocks for the roadway, and paving methods.

1926.

81. BUILDING double-decked highway in trap rock cut. (Eng. N. 97:415-16, 1926). diagr., illus.
Special excavation and concreting procedure required for the N.J. highway approach to the tunnel.

SHIELD

1890.

82. THE SHIELD for the Hudson river tunnel. (Eng. N. 23:257, 1890). diags.
Explains operation of the Baker shield.

SHIELD

1890.

83. THE HUDSON tunnel shield. (Eng. N. 24:54-55, 1890). illus.
Description and detailed illustrations of the frame and cutting edges, diaphragm, and the nearly completed shield.

1902.

84. A FREEZING process for building the river tunnel of the Pennsylvania R.R. at N.Y. (Eng. N. 48:472-73, 1902),
Explains the proposed plan of Charles Seeysmith.

1904.

85. BURR, S.D.V. The Hudson river tunnel. (In two parts).
(Iron age. v. 73: June 2, p.1-5; June 9, p.1-2, 1904).
diagr., illus.
Compares the earlier methods of pilot and shield with the newer methods of construction which carried the work to completion.
86. THE REMARKABLE progress of the Hudson river tunnel for the N.Y. & N.J.R.R.Co. (Eng. N. 52:420-21, 1904). illus.
Summary of the major problems overcome, including several views of the shield.

1907.

87. HILDIGE, H.T. Mining operation in N.Y. city and vicinity.
(Amer inst. mining eng. Trans. 37:360-97, 1907). diagr., illus.
Methods and appliances of "mines" (i.e., tunnels) being developed in N.Y., especially the various types of shields used in the Hudson Manhattan and Pennsylvania R.R. tunnels.

1918.

88. O'ROURKE, John F. Multiple-air-chamber shield for large tunnels.
(Eng. N. 80:563-65, 1918). diagrs.
Explains how his application for a patent follows fundamental principles of shield construction for compressed air tunnels.

1921.

89. HOLLAND, C.M., and Olaf Heff. Shield vs. trench method for Hudson vehicle tubes. (Eng. N. 86:764-66, 1921).
Summary of the best points of both methods. Mr. Heff favors digging a trench in the bottom of the river, while Mr. Holland defends the methods of boring with a shield, (with excerpts from his report to the Tunnel commissions).

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DURING a recent blowout in the Hudson Tunnel tube, when there was a sudden inflow of silt and water into the tunnel, the safety screen served its purpose well. The two tubes, 30 feet in diameter, are being driven through the river mud by the compressed air method, the inward pressure of the plastic mud being counterbalanced by the outward air pressure against the mud. The tunnel is excavated by means of a massive steel shield or cap, which covers its forward end and extends several feet back over the completed portion of the tunnel, around which it fits with a few inches clearance. The shield is advanced by powerful hydraulic jacks which thrust it bodily through the yielding mud.

The blowout was caused by the compressed air forcing its way back between the tunnel lining and the shield and escaping at the rear of the shield. At this point the mud was unusually soft. Under the action of the air it was churned up and thrown into suspension, and the air broke through. This was accompanied by an inflow of water to the tube, where it steadily rose, driving the men to shelter. To meet such an emergency, there is a bulkhead, extending from the roof and covering the upper half of the tube. The water can rise to the bottom of the bulkhead, but is restrained at that level by the air pressure. When the blowout occurred, the men had only to run back to this shelter, from which they could escape

through the airlock. The mishap was remedied by dumping a few bargeloads of stiff clay above the tube.

The air pressure required within the tube is determined by the pressure against the outside of the tube due to the load of mud and water above it. For a given depth of the tube below water level, the pressure will be determined by the depth of the mud, since the mud weighs, say, 100 pounds, and the water 62.4 pounds, per cubic foot. The depth of the water and therefore of the mud is determined by sounding, and the necessary air pressure determined accordingly. An undetected shallowing of the mud would reduce the load on the tube and here equilibrium being destroyed, the air would break through.

HOW AN EMERGENCY SCREEN SAVED LIFE IN HUDSON TUNNEL BLOWOUT

SURVEYING

1912.

90. NOBLE, Frederick C. Notes on a tunnel survey. (Amer. sec. civil eng. Trans. 75:68-111, 1912). diagra., maps, plates.
Description of surveying methods used in construction of the East river tunnels, 1903-08. G.D. Snyder discusses the Hudson-Manhattan, and B.F. Cresson the Pennsylvania tunnel methods, pages 80-90, and 91-92, respectively.

1929.

91. SURVEYS for the Holland tunnel. (Amer. sec. civil eng. Proc. 55:630-32, 1929).
Abstract of discussion on a technical paper by C.L. Crandall.

WORKING AND HEALTH CONDITIONS

1890.

92. A COMPRESSED air hospital. (Eng. N. 23:557, 1890).
Describes the chamber devised by C.E. Meir.

1909.

93. JAPP, Henry. Caisson disease and its prevention. (Amer. sec. civil eng. Trans. 65:1-37, 1909). charts, diagra.
Studies made as engineer on the Pennsylvania East river tunnels. Dr. J. Leemis and W.L. Saunders discuss experiences in the North river tunnels; p. 29-32. Also published in its Proceedings, v. 35, p. 378-400, 778-87, 1909.

1924.

94. HOW an emergency screen saved life in Hudson tunnel blow-out. (Sci. Amer. 131:5, 1924), illus.
See Plate II.

1928.

95. HOPKINS, Albert A. Combating the "bends". (Sci. Amer. monthly. 1:328-29, 1928), illus.
Discusses the dangers of compressed-air illness, explaining the equipment, working conditions, and careful medical attention given to the workers.

EQUIPMENT AND MAINTENANCE

1907.

96. HAZLETON, Hugh. The new steel cars of the Hudson companies. (Railrd. gaz. 42:831-34, 1907); diagrs., illus.
Outlines the design of the Hudson-Manhattan cars, summarizing the more important features of construction.

1911.

97. GIBBS, George. Service equipment of the Pennsylvania tunnels and terminal, N.Y. city. (Eng. N. 66:402-06, 432-35, 1911). diagrs., illus.
Describes the completed tunnel equipment, including ventilation, signal systems, etc.

1921.

98. TRAFFIC policies for vehicular tunnels endorsed. (Eng. N. 86:293-94, 1921).
Summary of the Advisory transportation committee recommendations as to width of road, fire hazard, etc.

1927.

99. METHOD of operating Holland vehicular tunnels. (Eng. N. 99:700-03, 1927). illus., plan.
Brief description of facilities in operation, safety precautions and personnel.

1928.

100. MAXWELL, J.P. The master "mind" of the Holland tunnel. (Elec. jour. 25:17-23, 1928); diagrs., illus.
Describes the electrical circuits and signals for the control of ventilation and of traffic.
101. SINGSTAD, Ole. A year's operating experience with the Holland vehicular tunnel. (Eng. N. 101:942-49, 1928); diagrs., illus.
Describes the traffic facilities and control system, and reviews the checks made on the ventilation and on the movement of the tunnel in silt.

LIGHTING

1924.

102. SHACKLEFORD, B.E., and D.W. Atwater. Study of lighting for Hudson river vehicular tunnel. (Illum. eng. soc. Trans. 19:638-61, 1924). diagrs., illus.
Considers general requirements of tunnel lighting, with tests and results of studies for the proposed Holland tunnel.

LIGHTING

1927.

103. ATWATER, D.W. Lighting of the Holland tunnel. (Elec. Jour. 24:347-51. 1927) 4 diags., illus.
Detailed description of the equipment for illumination.

VENTILATION

1898.

104. FOX, Francis. The ventilation of tunnels and buildings. (Inst. civil eng. Minutes of proc. 136:1-88. 1898) 4 diags., tables.
A summary of contemporary practice on ventilation in general. Includes discussion by E.W. Meir on practice in the Hudson tunnels: p. 25-26. Also, Condensed, in Engineering News, 42:131-34, 1899.

1910.

105. DAVIES, J.V. Tests of ventilation in the Hudson and Manhattan railroad tunnels. (Amer. soc. civil eng. Trans. 69:414-17. 1910) 4 diags.
Letter, taking part of the discussion on the N.Y. tunnels of the Pennsylvania railroad. Includes tests on air resistance in the Hudson-Manhattan tunnels. (Included in Item 7, reprint of this volume of the Transactions).

1912.

106. DAVIES, J.V. Air resistances to trains in tube tunnels. (Amer. soc. civil eng. Trans. 75:982-1029. 1912) 4 diags., plates.
Results of experimental tests made in tunnels of the Hudson-Manhattan and Pennsylvania R.R. tunnels. With discussion.

1918.

107. THE PROPOSED N.J.-N.Y. vehicular tunnel. (Heat. & vent. mag. v. 15: April, p. 25-33, 1918) 4 diags., map.
Conclusions drawn from tests on ventilation, made under the direction of G. Alleman at Swarthmore college.

1919.

108. THE PROPOSED vehicular tunnel under the Hudson river. (Sci. Amer. 120:222-23, March 8, 1919) 4 illus.
Favors the proposed Goethals' tunnel plan as satisfactorily solving the problem of ventilation.

VENTILATION

1921.

109. FIELDNER, A.C., and others. Gasoline losses due to incomplete combustion in motor vehicles. (Jour. ind. & eng. chem. 13:51-58, 1921), diags., illus., tables.
With A.A. Straub and G.W. Jones. Outlines the methods and results of the experiments held at the Pittsburgh experiment station to estimate the percentage of carbon monoxide in the proposed Holland tunnel.

110. TESTS fix vehicle tunnel ventilation policies. (Eng. N. 86:602-03, 1921),
Summarizes results of experiments conducted jointly by the U.S. mines bureau and the N.Y.-N.J. tunnel commissions. Letter from Walter I. Aims suggests that the capacity of the ventilation system will prove too small for the needs of the tunnel, (p.960-61).

111. VENTILATION of the N.Y.-N.J. vehicular tunnel. (Amer. sec. heat. & vent. eng. Jour. 27:303-20, 1921), diags., illus., map, plans.
Discusses the problem, outlining the program for experiments to be conducted by the U.S. mines bureau.

1922.

112. SKERRETT, Robert G. Research settles the problem of tunnel ventilation. (Sci. Amer. 126:169-70, 1922), diags., illus.
Outlines the experiments conducted at Illinois univ., and at Bruceton, Pa., to determine the best system for use in the Holland tunnel.

1925.

113. FLUSHING system advocated for ventilating Holland vehicular tunnel. (Heat. & vent. mag. v. 22: April, p. 77-79, 1925), plans.
James S. Seymour presents the advantages of an air current along the length of the tunnel, as against the adapted system of cross ventilation from roadway to ceiling.

1926.

114. FIELDNER, A.C., and others. Ventilation of vehicular tunnels. (Amer. sec. heat. & vent. eng. Jour. 32:17-36, 79-100, 153-58, 289-300, 387-404, 479-86, 547-57, 617-27, 658-78, 701-18, 757-66, 817-32, 1926), diags., illus., tables.
Includes articles by A.C. Fieldner, G.R. Greenslade, H.C. Howarth, G.W. Jones, F.V. Meriwether, H.R. O'Brien, J.W. Paul, R.R. Sayers, A.A. Straub, and W.P. Yant.
Detailed discussion of all technical and medical phases of the subject. Presents a series of reports of investigations made by the Mines bureau at its Pittsburgh experiment station, Yale university, and Illinois university. Foot-note references.

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115. KATZ, S.H., and others. A carbon monoxide recorder and alarm. (U.S. Mines bureau. Tech. paper 355, 1926. 35p.). diagrs., illus., tables.

With D.A. Reynolds, H.W. Prevert, and J.J. Bloomfield.
Review of data and tests made by the Pittsburgh experiment station since the start of experiments for the Holland tunnel ventilation in 1917.

116. SINGSTAD, Ole. The Holland tunnel. (Amer. inst. min. & met. eng. Trans. 74:366-83, 1926). diagrs., plans.

Outlines the characteristics of the ventilation system. The same volume includes his comment on: The Atkinson formula, calculations for the ventilation of the Holland tunnel. (p.281-82).

1927.

117. BEDWORTH, R.E., and E.B. Dawson, 'The ventilation of the Holland tunnel. (Elec. Jour. 24:533-39, 1927). diagrs., illus., map.

General problems of ventilation, with emphasis on the electrical meter equipment.

118. STUDIES and methods adopted for ventilating the Holland vehicular tunnels. (Eng. N. 98:934-39, 1927), diagr., illus., plan.

Discussion of the problem, tests, equipment, and maintenance of ventilation control.

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119. KATZ, S.H., and H.W. Frevert, 'Chemical control of ventilation at the Holland tunnel. (Ind. & eng. chem. 20:564-70, 1928). diagr., illus.

Principle of the carbon monoxide recorder, and data obtained during the first two days of operation of the Holland tunnel.

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120. SINGSTAD, Ole. Ventilation of vehicular tunnels. N.Y., 1929. 20p., 5 pl.

Paper read before the World engineering congress, Tokio, 1929. Planning, results of investigations, and summary of the characteristics of the Holland system.

1930.

121. DAVIS, A.C. Development of the ventilation system of the Holland tunnel. (Heat.-piping. 2:866-74, 1930). diagrs., illus.

Review of the Mines bureau tests, and of the characteristics of the ventilation system. Excerpt in Domestic eng., v.134, Feb. 7, p.83-4, 86, 1931.

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